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Black-tailed Prairie Dog Monitoring Protocol for Seven Prairie Parks

Northern Prairie Wildlife Research Center Inventory and Monitoring Protocol

U.S. Department of the Interior
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Black-tailed Prairie Dog Monitoring Protocol for Seven Prairie Parks

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PREFACE

The original draft of the Black-tailed Prairie Dog Monitoring Protocol for Seven Prairie Parks was prepared by the first four authors in March 1998. The final protocol was prepared by Drs. Glenn E. Plumb, William M. Rizzo, and Gary D. Willson.

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1.0 INTRODUCTION

1.1 <u>Historical distribution and current status</u>

Prairie dogs (*Cynomys* sp.) once inhabited about 10 to 20% of the short and mixed-grass prairies of the United States (Anderson et al. 1986). According to conservative estimates, only 2% of this historic range remains occupied (U.S. Fish and Wildlife Service 2000). The proximate causes for this decline include habitat loss due to cropland conversion and urbanization, habitat modification and fragmentation, disease, and poisoning (U.S. Fish and Wildlife Service 2000). The introduction of sylvatic plague (*Yersinia pestis*) into North America also is capable of causing massive prairie dog dieoffs (Barnes 1993; Cully 1993). Any future decline of prairie dog populations will likely be a direct consequence of additional habitat loss and impacts from increased habitat fragmentation. Habitat fragmentation will increase colony isolation within the landscape. A decrease in the size of prairie dog colonies and increased colony isolation will increase the risk of localized extinction and reduce the potential emigration of prairie dogs which would otherwise form new colonies. Isolation of prairie dog populations may help protect colonies from disease through lack of contact with infected populations, but once plague is introduced, small colonies would be at higher risk of extirpation.

The past status of the black-tailed prairie dog (BTPD), *Cynomys lucdovicianus*, in lands managed by the National Park Service (NPS) has not been well-documented. There are 29 NPS units within the historic range of the BTPD. A 1995 survey of resource managers in these units on the historical abundance and distribution of BTPDs and associated biota showed that crucial historic baseline data is sketchy at best and is generally incompatible between parks. Twelve NPS units are known to have been historically populated by BTPDs (Figure 1). But by the 1970s, unknown causes resulted in the extirpation of BTPDs from 4 units south of the southern borders of Colorado and Kansas. These southern parks probably supported relic BTPD populations fragmented from once larger populations by the processes of extirpation described above. Random demographic and environmental effects on the resulting small populations also may have played a role in their demise. While no records of BTPD control in these southern units were reported, plague has been historically active at or near these 4 parks. However, managers are unsure if plague was the primary driving force of these extirpations. Prior to 1995 BTPDs were intentionally extirpated through chemical control at Little Bighorn Battlefield National Historic Site, Montana.

In the central and northern portions of the historic range, the 7 park units used to develop this protocol currently support BTPD populations [Badlands National Park (BADL) in South Dakota, Bent's Old Fort National Historic Site (BEOF) in Colorado, Devil's Tower National Monument (DETO) in Wyoming, Fort Larned National Historic Site (FOLA) in Kansas, Scotts Bluff National Monument (SCBL) in Nebraska, Theodore Roosevelt National Park (THRO) in North Dakota, and Wind Cave National Park (WICA) in South Dakota]. Some of these parks (e.g., BEOF, DETO, FOLA, and SCBL), are small units supporting only a single BTPD colony (<16 ha and 400 BTPDs). The larger parks (BADL, THRO, and WICA) are extensive landscapes capable of supporting a variety of native biota. Each of these parks refer to existing resource management plans for guidance in managing BTPD population abundance and distribution.

From 1995 to 1997, this monitoring protocol was developed, tested, and implemented. Digital maps of BTPD colonies in each park were generated and supplied to the parks.

1.2 Review of black-tailed prairie dog systems ecology

The ecological concerns relevant to BTPD conservation management include: 1) threats to biodiversity through increased localized extinction and reduced migration of prairie dogs and associated species, 2) disturbances resulting in landscape changes that reduce or eliminate normal BTPD ecological processes or patterns, and 3) prairie dog populations at risk from disease and, possibly, genetic depression.

Substantial BTPD research has been conducted over the past 3 decades at the individual colony scale. Prairie dogs strongly modify the structure and function of the systems in which they reside through intense, continual herbivory and soil disturbance. Herbivory by BTPDs modifies the morphology, structure, and nutritive value of individual plants (Cid et al. 1989; Brizuela et al. 1986; Detling and Painter 1983; Holland and Detling 1990; Jaramillo and Detling 1988). The duration of colonization modifies the microhabitat, resulting in disturbance gradients that include altered rates of microbial activity, nutrient cycling in soils, and water balance in plants (Archer and Detling 1986; Holland and Detling 1990; Whicker and Detling 1988). Plant community composition also changes as a function of the duration of colonization, with the highest plant diversity occurring with intermediate disturbance (Agnew et al. 1986; Archer et al. 1987; Bonham and Lerwick 1976; Cincotta et al. 1989; Klatt and Hein 1978).

Herbivory and soil disturbances are hypothesized to substantially change root dynamics through modification of nematode/root interactions (Ingham and Detling 1984). These impacts create major colony edge gradients and differences in plant community structure between colonies and adjacent areas resulting in a complex habitat mosaic. This habitat mosaic has been suggested to be beneficial to other species (Agnew et al. 1986; Sharps and Uresk 1990) such that a BTPD complex (complex = multiple colonies) may support enhanced habitat and species diversity. In mixed-grass prairie, approximately 40% of vertebrate wildlife species have been described to have some association (i.e., from obligate to accidental) with prairie dog colonies (Sharps and Uresk 1990). A critical review of the assumptions about prairie dogs as a keystone species was conducted recently by Kotliar et al. (1999). This review confirmed that although prairie dogs affect a number of ecosystem level functions, their influence on prairie vertebrates may be less than suggested by other authors. Indeed, Kotliar et al. (1999) found that there was quantitative evidence of dependence on prairie dogs for only 9 of the 208 species listed in the literature as observed on or near prairie dog colonies. However, Kotliar et al. (1999) concluded that prairie dogs provide unique ecosystem functions not duplicated by any other species and that continued decline of prairie dogs may lead to erosion of biological diversity and landscape heterogeneity.

BTPD colonies also may function as distinct "islands" of habitat for avian communities (Reading et al. 1989). However, the small size and isolation of "island" fragments increase their vulnerability to landscape degradation. Changes in land-use and disturbance regimes will likely reduce recolonization and species richness over time as more resource-demanding species (e.g., specialists such as the black-footed ferret and burrowing owl) become locally or regionally extinct (*sensu* Lomolino 1986). Local extinction rates should be lower on larger patches while immigration rates should be lower for more isolated patches. The degree to which croplands, roads, and major features such as rivers, badlands, or forests represent important barriers to the dispersal of prairie dogs and associated species is largely unknown. Indeed, if landscapes become strongly fragmented, the structure of the associated vertebrate communities could become more strongly influenced by selective extinction than migration. Some evidence suggests that there are optimum patterns of colony complexes that underpin obligate species metapopulation variability (e.g., the black-footed ferret; Biggins et al. 1993). However, attempts to describe optimal models of BTPD colony patterns for additional species or groups has barely begun (Bevers et al. 1996; Reading et al. 1989).

Reduction of BTPD populations also may increase their susceptibility to the effects of disease and genetic depression. Acute infectious and septicemic diseases, such as sylvatic plague (the term for bubonic plague in wildlife populations) and tularemia, can strongly regulate BTPD population abundance and demographics (Barnes 1993; Hopla 1974). The mechanisms by which plague enters a prairie dog colony and becomes epizootic and remains enzootic are largely unknown, but localized morbidity from sylvatic plague is underpinned by localized biological and environmental factors (Cully et al. 1997). Once introduced, plague may become immediately epizootic (Cully et al. 1997) or become epizootic only under conditions of prairie dog stress (e.g., food shortage, harsh winter, overcrowding) (Raynor 1985). Regardless of the causes, epidemics result in massive to near-complete mortality (> 95%) with slow or negligible recovery. The limited available evidence suggests that BTPDs have not experienced genetic depression; i.e., reduction in heterozygosity; (Daley 1992). This may be due to the potential for rapid population recovery and occasional successful migration.

1.3 <u>Objectives of black-tailed prairie dog monitoring</u>

With the growing emphasis on ecosystem management, the NPS must possess protocols for monitoring BTPD status within an ecosystems context. Development of long-term prairie dog datasets at the 7 prairie parks with BTPDs should concentrate on those attributes of BTPD populations that will permit managers to track status and trends. The purpose of this report is to describe a BTPD monitoring protocol with common applicability in all NPS units that will allow estimation of: 1) BTPD density and total colony abundance, 2) size of BTPD colonies and colony maps, and 3) surveillance of sylvatic plague. Each park unit will then be able to use the methods described in this protocol to develop monitoring programs that fit park management objectives while simultaneously collecting data that is congruous with data being collected by other NPS units. For example, the protocol could be used to assess the effects of prescribed fire, grazing, prairie restoration efforts, and other management practices on BTPD populations. Because BTPD populations are linked to plant community dynamics, park personnel may also wish to monitor plant communities. Parks with a need for plant community monitoring are referred to the plant community monitoring protocol in development by Buck et al. (in preparation).

The methods described in this monitoring protocol for estimation of BTPD density and total colony abundance are intended not as rigorous quantitative estimates of population density and size (e.g., as would result from a mark and recapture study), but to provide a relatively simple and cost-effective procedure for tracking population trends over time.

2.0 BLACK-TAILED PRAIRIE DOG ABUNDANCE MONITORING

2.1 Background

The sampling frequency for long-term monitoring of BTPD population abundance depends on the temporal scale dynamics of interest to each individual park. Annual sampling is required to understand inter-annual (every year) changes while decadal scales of variation require sampling only 2 to 3 times per decade. Regardless of the frequency, sampling should occur during June and July following emergence above ground of young BTPDs but prior to dispersal of the young-of-the-year. Also, at this time of year the BTPD-induced vegetation clip line colony "edge" is most easily discerned. BTPD abundance is based on a visual count of the maximum number of BTPDs in a sampling plot. Severson and Plumb (1998) found that visual counts using the sample maximum count rather than the mean number counted yielded a significant predictive relationship with populations estimated using more expensive mark and recapture techniques (Fagerstone and Biggins 1986; Menkens et al. 1990). In addition, a 4-ha plot was found to be adequate for estimation of BTPD density (Severson and Plumb 1998). In the Severson and Plumb (1998) linear model $P = ([Y/S_p] - 3.04)/0.40$; $r^2 = 64.6$, $P < 0.0001$, where:

P = the estimated density of prairie dogs (individuals ha^{-1}) in the total area sampled,
S_p = the total area sampled, either the 4-ha sample plot, or total colony area if less than 4 ha; and
Y = the maximum visual count recorded over all plot counts.

Alternatively, burrow counting techniques were found to be an inadequate estimator of BTPD abundance (Severson and Plumb 1998).

Using the original replicated 4-ha sample plot data from Severson and Plumb (1998), the standard error (SE) of P can be calculated from the relationship:

$$\text{Variance }(P) = MSE/b^2\,(1 + 1/n + [P - \bar{x}]^2/\sum [x_i - \bar{x}]^2) \text{ where}$$

MSE = mean square error = 10.1
$b = 0.4$
$n = 24$
$\bar{x} = 18.4$
$\sum [x_i - \bar{x}]^2 = 2512$

Variance (P) then becomes: Variance $(P) = 66 + 0.025\,(P - 18.4)^2$, and SE $(P) = \sqrt{\text{Variance }(P)}$ (Neter et al. 1990).

2.2 Field methodology

The field methodology follows the sampling approach described by Severson and Plumb (1998). It requires setting up a 200-m x 200-m (4-ha) plot in each year a count is made (Figure 2; section 2.2.1) and conducting the visual count of BTPDs (section 2.2.2). The plot should be established at least 24 hours prior to conducting counts in order for the prairie dogs to return to normal behavior following the intrusion of people walking through the colony. For a colony < 4 ha, counting the complete colony should be done without establishing staked plots.

2.2.1 *Plot setup*

1. The following guidelines are for a 200-m x 200-m (4-ha) plot. During the morning (recommended time is between 0800 and 1100, when prairie dogs are active aboveground), scan the colony to look for areas of relatively high prairie dog activity (i.e. areas with the most individuals and activity). Higher activity areas are used because the purpose of the sampling is to generate long-term datasets using a repeatable design (versus selecting a priori areas within a colony with low aboveground BTPD activity). Mentally picture the plot layout on the ground and select a starting corner point. Select a location within the colony with the fewest visual obstructions if any exist.

2. Set a fluorescent-orange-painted wooden stake at the starting point, and use a compass to get the first bearing you want to follow for the plot boundary. Wooden stakes are recommended because they are easy to acquire, their light weight makes them easy to transport, and they are easy to set with a mallet. However, other types of stakes (e.g., metal) could be used. If desired, determine locations of stakes or plot corners using the global positioning system (GPS) technology used for colony mapping (section 3.0).

3. Pace the 200 m on the aforementioned bearing and place another orange-painted, wooden stake at that point. If desired, the plot side lengths can be determined with a 100-m measuring tape.

4. Calculate the 90° angle away from the previous bearing. This will be the next plot side boundary. Pace or measure another 200 m. Continue turning the corners until you reach the first stake set.

5. Keep in mind the necessity of visually relocating the corner stakes during visual counts (described in section 2.2.2) and make necessary adjustments, such as matting down vegetation near a stake, flagging, or some other method of making the stakes visible.

2.2.2 *Conducting visual counts*

1. Locate an elevated platform (eye level ≥ 3 m above ground level; e.g., a ladder or similar elevated platform such as a mobile deer hunting stand) in the southeast or northeast corner of the 4-ha plot to reduce observer glare from the rising sun. .

2. The ladder and observer should be in place at least 1 h before the count starts to condition the prairie dogs to the observer's presence. Counts should begin about 1 h after sunrise.

3. Using 7 x 35 binoculars or larger, conduct a visual sweep across the plot counting all prairie dogs seen. Record all data on the visual count data sheets (Figures 3 and 4). The time between the start of the current count and the start of the next count should be 15 minutes. Conduct a minimum total of 8 counts. Finish between 1000 and 1100 hour each morning. Measure weather conditions with a standard fire weather kit and note them on the data sheet. Weather conditions can affect counts. Although Powell et al. (1994)

stated that weather effects on prairie dog activities were minimal, strong winds can restrict aboveground activity. Menkens and Anderson (1993) and Severson and Plumb (1998) suggest counting during moderate weather, since prairie dogs are not active aboveground during rainfall events, high winds and/or cold temperatures. Based on their suggestions, counts should be made when wind speeds are < 32 kph (20 mph), and temperatures are > 10 °C (50 °F). Counts should also not be made when it is raining.

5. Continue these counting procedures for 2 additional mornings for a minimum of 3 visual counts conducted on consecutive days, if possible.

2.3 Calculating prairie dog total colony abundance

Using the predicted density estimate, P, derived above, the total BTPD colony abundance, T, is calculated as: $T = (S_c)(P)$, where S_c is the total colony area (ha) derived from the colony mapping (i.e., GPS survey). The SE of the abundance estimate is derived from:

Variance (T) = $(S_c)^2$ (Variance [P]), and

SE (T) = $\sqrt{\text{Variance (T)}}$

(Neter et al. 1982). Extrapolating the density estimate to the total colony area will result in an overestimate because the counted plot is non-randomly located each year in an area of high activity, because there is variability in BTPD density within a colony, and because there is variability in deciding whether outlying burrows are included in the colony polygon (section 3.1 below). However, these sources of variability remain constant from year-to-year, so this procedure can still provide a method for tracking changes in total colony abundance over time.

2.4 Interpreting changes over time

Because the two BTPD metrics of interest, density (P) and abundance (T), represent a single annual value derived from the calculations above, there are limited options for statistical comparisons. Unreplicated data could be tested using the Z-test (Neter et al. 1982), but that test does not account for potential autocorrelation problems which could occur especially if surveys are conducted annually. The best alternative is to calculate confidence intervals for the metrics, and compare those between years (Johnson 1999). Estimates with broadly overlapping intervals are not likely to be significantly different, whereas those with non-overlapping intervals would be clearly significantly different. The 95% confidence intervals for density and abundance, or any normally-distributed variable (Sokal and Rohlf 1969) can be calculated as:

Lower limit, P = P - 1.96 [SE(P)]
Upper limit, P = P + 1.96 [SE(P)]

Lower limit, T = T - 1.96 [SE(T)]
Upper limit, T = T + 1.96 [SE(T)]

where P and T are the quantities derived as described in sections 2.1 and 2.3, respectively. The critical value of 1.96 is obtained from statistical tables (Rohlf and Sokal 1981) and represents the area of the t-distribution containing 95% of the parameter estimates for α=0.05 with n-1 degrees of freedom. The value for the standard errors of P [SE(P)] and T [SE(T)] are those calculated in sections 2.1 and 2.3, respectively.

When surveys have been conducted long enough to provide over 5 years of data, simple linear regression analyses also could be used to assess changes over time.

3.0 BLACK-TAILED PRAIRIE DOG COLONY MAPPING AND SIZE MONITORING

3.1 Background

The availability of GPS for delineating irregular land-surface polygon boundaries and sizes in conjunction with PC-based Geographic Exploration Systems, such as ArcView®, now permits easy mapping of BTPD colonies. NPS personnel should use whichever systems are available, and follow the appropriate procedures for those instruments, which are supplied by the manufacturers. In addition, ecosystem level parameters, such as species richness/area relations, and indices of isolation, such as distance to nearest neighboring colony, could be obtained. A primary difficulty in BTPD colony mapping is deciding what constitutes the colony "edge." GPS measurement errors in conjunction with errors in delineating the colony edge could combine to produce inconsistent estimates of colony size and shape.

During the summers of 1995 and1996, 41 BTPD colonies in the 7 parks were mapped with GPS units using 2 different criteria for delineating the colony edge (Severson and Plumb 1998). Colonies were first mapped by following only the edge line of prairie dog clipped vegetation. Each colony was then mapped by circumscribing the colony by inclusion of all active burrows (*sensu* Biggins et al. 1993) that were within 5 meters of vegetation grazed by prairie dogs. Other active "satellite" burrows more than 5 meters from grazed vegetation were ignored. Due to problems with GPS equipment and operator errors, only 36 colonies yielded paired datasets of colony area with a range of 0.41 to 205 ha. The vegetation clip line and active burrow line techniques were compared by paired t-test ($P \leq 0.05$; Snedecor and Cochran 1980) for estimates of colony area and perimeter.

There was a significant difference between the two colony edge criteria for colony area ($t = 3.714$, $df = 35$, $P = 0.001$, mean difference [± standard deviation] = 4.5 ± 7.3 ha). There was no significant difference between the two colony edge criteria for colony perimeter estimates ($t = 0.660$, $df = 35$, $P = 0.514$, mean difference = 76.3 ± 693.0 m). These data suggest that if either criterion were used exclusively, important variation in colony size and perimeter would be missed. It is important to remember that a prairie dog colony is a disturbed vegetation and soil patch with a diffuse boundary that reflects a gradient from highly disturbed to less disturbed to undisturbed vegetation and soils. Additionally, a vegetation clip line may not always be discernible due to bare ground, drought, or other factors. As such, a protocol that aims to generate repeatable delineation of a colony "edge" must incorporate visually detectable evidence of activity by prairie dogs that can be reliably followed. Because the clip line criteria is the most easily discernible visual cue, it should be the first criteria followed in GPS mapping. When the clip line disappears or fades beyond visual recognition, the colony edge can continue to be delineated by following the active burrow line within 5 meters of the closest BTPD grazed vegetation. The active burrow line is followed until it reconnects with the vegetation clip line or until the vegetation clip line is discernible again. This protocol was developed for mixed-grass prairies. During drought conditions, clip lines may not be useful in delineating colony edges in shortgrass prairies. Application of the mapping procedure of this protocol to the typical drought conditions of shortgrass prairies may require testing and revision of these mapping procedures.

Another difficult challenge is to correct for the area(s) of unsuitable habitat within a colony polygon. Clearly, large, permanent features such as perennial streams should be excluded from the area estimate. However, there are other natural gradients in habitat suitability within a colony polygon that make it difficult to determine whether such areas should be included. If the questionable area is small and/or transient, it is probably not significant enough to warrant the extra effort to determine the excluded area. The ultimate question of inclusion/exclusion will likely rest on the experience of the observer.

3.2 Field methodology

3.2.1 *Delineating and mapping the edge of a prairie dog colony*

1. In general, GPS mapping should be done with a minimum PDOP of 6 and an elevation mask of 15 degrees. Refer to the GPS user manual for manufacturer specifications.

2. Remember that delineation of the colony edge is an exercise in creating an artificial margin along a disturbance gradient. Therefore, consistency and precision must be balanced with practicality and common sense.

3. Before conducting GPS mapping, use colored pin flags to mark the edge of the colony.

4. Select a starting point with a flag, and begin walking the colony edge in either direction.

5. Use the following criteria to delineate the colony edge:
   a. Visual identification of the dominant vegetation clip line, when present.
   b. When the continuity of a vegetation clip line disappears or cannot be reasonably determined, continue to encircle the colony with an imaginary line that incorporates the extent of the active burrows (e.g., > 7 cm burrow opening with fresh scat within 0.5 m, *sensu* Biggins et al. 1993) within 5 meters of vegetation recently grazed by BTPDs. There may be exploratory burrows at great distances from the main colony, but burrows more than 5 meters from actively BTPD-grazed ground should be excised. Otherwise, extensive areas of uncolonized grassland could be included (Figure 5).

6. While walking the colony edge, place the pin flags approximately 10 meters apart or at shorter, reasonable intervals that will clearly delineate undulating changes in the perimeter of the colony polygon. The recommended flag spacing is based on the senior author's experience of the optimum interval.

7. Completely walk the entire colony edge, arriving back at the initial flag, and thus closing the colony polygon.

8. Map the area of the colony polygon using the GPS unit according to the manufacturer's specifications.

9. Following downloading and differential correction of the mapping data, files should be exported as ArcView® shape-files. Once in ArcView®, add a field named Map_Label to the attribute table. Within this field, label the polygon with the park, year, and site (e.g., SCBL_1997_1 = Scotts Bluff, 1997, site 1). The shape-file can be merged with files from various years to create a single file containing a polygon for each year. Through the field Map_Label, the maps can be linked to a Microsoft Access® database. Following the creation of the original shape-file the following information should be provided for generation of appropriate metadata: 1) Originator - name of organization or individual that developed the dataset, 2) Abstract - a brief narrative summary of the dataset, 3) Calendar_Date - the year (and optionally month, or month and day) for which the dataset corresponds to the ground, and 4) Projection - projection and datum under which information was collected (i.e., UTM zone 13N, NAD83). Finally, maintain a log file showing when data were added. Include the manufacturer of the GPS units employed in the metadata. As GPS technology improves, errors will decrease, and this information may be important in assessing trends.

4.0 DATA MANAGEMENT

The BTPD population and mapping data is stored in an Access® database (Table 2). Only the raw count data is archived. The ArcView® mapping data is accessible through the Tbl_Map field.

5.0 SYLVATIC PLAGUE SURVEILLANCE

5.1 <u>Background</u>

Plague is a flea-transmitted disease caused by the bacterium *Yersinia pestis*, a relatively fragile organism that can remain viable for some time if protected by organic material or by cool, damp soils such as those found inside of fossorial rodent burrows (Orabona 1988). Plague is most commonly transmitted animal-to-animal and animal-to-human by the bites of family host-specific infective fleas that have acquired the organism by blood feeding followed by bacterium incubation inside the flea host. Less frequently, the organism enters through a break in the skin by direct contact with tissue or body fluids of a plague infected animal (CDC 1992). In humans, primary plague pneumonia is transmitted by inhaling infected droplets expelled by the coughing of an animal or person with pneumonic plague. In humans, the onset of the symptoms of classic bubonic plague appear within 2 to 6 days of exposure and are typified by painfully swollen lymph node(s), fever, headache, and rapid progression via the blood stream to plague septicemia.

Sylvatic plague (plague is termed sylvatic in animals, bubonic in humans) is characterized by explosive and often devastating sporadic or periodic epizootics among susceptible rodent and flea populations. To date, members of 8 orders, 95 genera, and more than

200 species worldwide have either tested plague-positive or have plague antibodies present that indicate previous exposure (Poland and Barnes 1979).

In 1936, plague was first documented in the Utah prairie dog (*Cynomys parvidens*) (Hubbard 1947) and by 1938 was documented in the Gunnison's (*C. gunnisoni*) and white-tailed prairie dogs (*C. leucurus*) (Kartman et al. 1962). It appears that localized morbidity of sylvatic plague is underpinned by localized biological and environmental factors. For example, infection rates and prevalence of plague in multiple species of flea vectors varied with altitude among Gunnison's prairie dog (Kartman et al. 1962). The secondary host role(s) of other colonial small rodent species (*Peromyscus* and *Spermophilus*) also varied across space and time (Cully et al. 1997).

The mechanisms by which plague enters a prairie dog colony, becomes epizootic, and remains enzootic are largely unknown. Plague could enter a colony by a readily infected but otherwise resistant host species such as the prairie rattlesnake *(Croatulus viridus),* burrowing owl *(Speotyto cunicularia*), badger (*Taxidae taxus*), by a moderately resistant species such as the coyote (*Canis latrans*) or swift fox (*Vulpes vulpes*), by a reservoir species such as the deer mouse (*Peromyscus maniculatus*), or by other infected prairie dogs. Once introduced, plague may become immediately epizootic (Cully et al. 1997) or become epizootic only under conditions of prairie dog stress (e.g., food shortage, harsh winter, overcrowding; Raynor 1985) Alternatively, plague can become endemic to some portion of the flea metapopulation and have only minor effects on prairie dogs until either environmental conditions favor flea population growth or prairie dogs become abnormally susceptible to infection (Raynor 1985).

Barnes (1982) strongly suggests that prairie dog density is an important driving factor of plague endemism. Initial epizootics largely occur in previously uninfected colonies and often require several years after the initial epizootic before the colony becomes susceptible to subsequent outbreaks. Periodicity of prairie dog activity also should influence epizootics. Black-tailed prairie dogs are active yearlong and thus are continually susceptible. Hibernating species of prairie dogs (i.e., Gunnison's or white-tailed) do not appear susceptible during winter but can suffer massive dieoffs shortly following spring emergence (Cully et al. 1997). Menkens (1989) suggests that in large prairie dog complexes, plague front(s) may exist wherein plague is actively killing prairie dogs but there may be other areas where populations are not impacted. Regardless of which mechanisms underpin plague epidemiology across prairie dog species and distribution, the short- to long-term consequences are massive to near complete mortality (> 95%) with slow or negligible recovery.

5.2 Sylvatic plague status

5.2.1 *Background* - Estimating the status of sylvatic plague can include: 1) surveillance of pathogen occurrence in wild vertebrate hosts, 2) surveillance of vector populations, and 3) detection of disease in humans or domestic animals (Moore and Gage 1996). Successful detection of wildlife disease outbreaks based on population serum sampling requires population(s): 1) with a known limited home range, 2) from which test sera can be easily obtained, and 3) that are susceptible and respond serologically but are not yet decimated by the disease under study. Prairie dog colonies not yet subject to a plague epizootic generally meet these criteria but represent a logistical paradox. To obtain sera for testing, prairie dogs must be intimately handled.

Thus, sampling to detect this virulent pathogen would, in the absence of extreme quarantine measures, necessarily subject personnel to unacceptable risks.

Sylvatic plague is not known to be currently active in BTPD population(s) in any NPS unit. Small parks (BEOF, DETO, FOLA, and SCBL) that support one BTPD colony each (< 16 ha and 400 individuals) are at highest risk of local extinction due to wildlife disease. Risk of dramatic depopulation or localized extinction should be smaller in larger parks (BADL, THRO, and WICA) with multiple colonies distributed across landscapes. Therefore, regional and local sylvatic plague surveillance, in the absence of an ongoing epizootic, generally takes the form of low-level local sampling paired with consistent liaison with state and local health departments and an informal surveillance network of biologically-oriented public agencies and individuals (Barnes 1982). Upon evidence of activity or detection of plague locally, further surveillance should be carried out by the appropriate state and local health agencies.

5.2.2 *Low-intensity surveillance for sylvatic plague* - A protocol for low-intensity surveillance of sylvatic plague in prairie dog colonies is described below. These guidelines provide only general approaches to plague surveillance that could be used and/or adapted by parks with BTPD populations. Necessarily, park-specific standards should be developed to meet state/federal guidelines and park-specific purposes and needs. Numerous factors could enter into the surveillance strategy for an individual park. Large parks (e.g,. BADL) may be too large to monitor annually; small parks, which are easier to monitor and are at greater risk from an epidemic, would be monitored annually. Managers may wish to monitor frequently in parks with nearby known sources of disease, etc. When parks deem plague surveillance is necessary, a minimum of 50% of the area of the total BTPD colony, or colonies, should be surveyed.

1. *Small park annual status surveillance (BEOF, DETO, SCBL, FOLA).* Park staff should conduct an annual visual survey, denoting on a copy of the most recent digital colony map the estimated spatial extent of the active colony and a visual estimate of prairie dog above-ground numbers (0-10, 10-30, 30-120, 120-360, > 360). Surveys should be done between 0800 and 1000 (period of peak BTPD activity) with a clear sky and low wind. Plotting abundance and distribution estimates across years will generate long-term trends from which dramatic order of magnitude deviations can be detected. Such deviations indicate substantial mortality and possible plague outbreak

2. *Large park annual status surveillance (BADL, THRO, WICA).* In larger parks, a combined vehicle/foot visual survey route that samples multiple colonies incorporating ≥50% of the total acreage of the prairie dog colony complex should be established. Park staff should conduct a yearly visual survey, denoting on a copy of the digital colony map the estimated spatial extent of the colony and an ocular estimate of prairie dog above-ground numbers (low < 5 BTPD/ha; mid 5 to15 BTPD/ha; high > 15 BTPD/ha). Surveys should be done between 0800 and 1000 (period of peak BTPD activity) with a clear sky and low wind. Plotting abundance and distribution estimates across years will generate long-term trends from which dramatic order of magnitude deviation can be detected. Such deviations indicate substantial mortality and possible plague outbreak.

3. Upon evidence of substantially reduced BTPD activity or detection of plague locally, further surveillance should be carried out by the appropriate state and local health agencies. Current contacts to be alerted at this level of concern are listed in Appendix A. Parks should maintain an updated list of state and local health agency contacts.

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Table 1. Summary status review of the black-tailed prairie dog (*Cynomys ludovicianus*) in the National Park Service, as of March 1998. Parks with black-tailed prairie dogs denoted as absent once supported the species during the past 50 years.

NPS unit	State	Park size (ha)[1]	Colony size (ha)[2]	% Park size[3]	Historic plague[4]	Historic control[4]
Badlands NP	SD	98282	1700	1.7	no	yes
Bent's Old Fort NHS	CO	324	6	1.8	no	no
Capulin Volcano NM	NM	321	absent	na	yes	unknown
Carlsbad Cavern NP	NM	18933	absent	na	yes	no
Devil's Tower NM	WY	545	9	1.6	unknown	yes
Fort Larned NHS	KS	291	6	2.1	unknown	no
Guadalupe Mountains NP	TX	4098	absent	na	yes	no
Lake Meredith NRA	TX	18209	absent	na	yes	no
Little Bighorn Battlefield NM	MT	310	absent	na	yes	yes
Theodore Roosevelt NP	ND	28521	241	0.8	unknown	yes
Scotts Bluff NM	NE	1216	2	0.2	no	yes
Wind Cave NP	SD	11455	414	3.6	no	yes

[1]The National Parks: Index 1993, Office of Public Affairs and Division of Publications, NPS, U.S. Department of the Interior, Wash., D.C.

[2]Estimates from all parks except Badlands National Park were derived from 1995 GPS mapping of all colonies in the respective parks. Four parks contain only a single colony, other parks contain a complex of many prairie dog colonies. The Badlands National Park estimate was derived from 1994 aerial photos, with interpretation of the park's north unit only. Estimates were rounded to nearest whole ha.

[3]Estimated percent of park size occupied by black-tailed prairie dog.

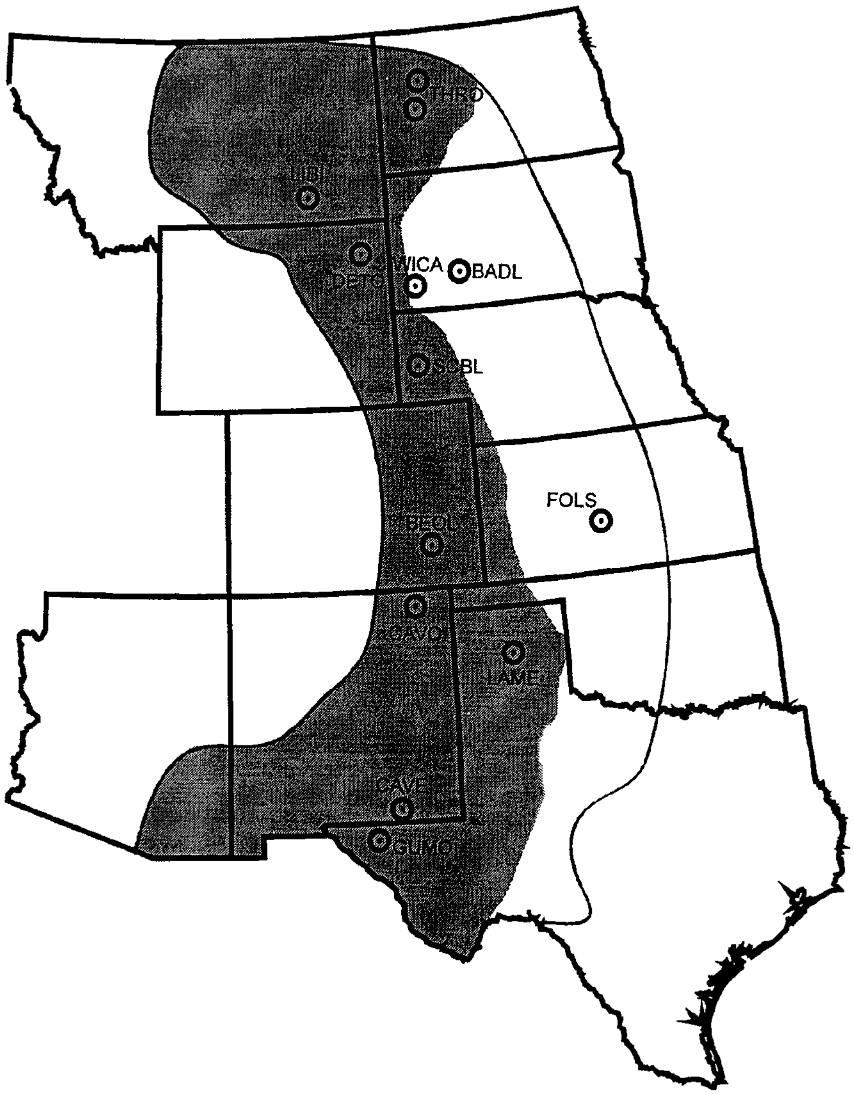
[4]Spring 1995 telephone survey of all NPS units located within historic home range of black-tailed prairie dog, Badlands NP files, Interior, SD.

Table 2. An example of a Microsoft Access® database and its tables and linkages for storage and handling of the black-tailed prairie dog monitoring data. Mapping information is stored in ArcView® files and linked through Tbl_Map.

Tbl_Map	**Tbl_Prairie_Dog_Counts**	**Tbl_Event**
∞ **Site_ID**	**Event_ID** ∞	1 **Event_ID** 1
Year	**Site_ID** ∞	Eventcode
Map_Label	Replicate	Date
	Count_of_Prairie_Dogs	Year
	Start_Time	Start_Time
	End_Time	End_Time
		Collector_1
		Collector_2

Tbl_Weather	**Tbl_Site**
Event_ID ∞	1 **Site_ID**
Site_ID ∞	SiteCode
Temperature	ParkCode
WindSpeed	Dogtown_Name
WindDirection	Observation_Point_ID
WindPosts	Zone
CloudCover	Northing
Precipitation	Easting
Comments	

Figure 1. Distribution of National Park Service units with current or historical populations of black-tailed prairie dogs (*Cynomys ludovicianus*), and area of historically active plague (gray shaded, adapted from Barnes 1982) within the species historical home range (adapted from Hall 1981). Park units supporting black-tailed prairie dogs include Badlands National Park (BADL), Bent's Old Fort National Historic Site (BEOF), Devils Tower National Monument (DETO), Fort Larned National Historic Site (FOLA), Theodore Roosevelt National Park (THRO), Scotts Bluff National Monument (SCBL), Wind Cave National Park (WICA). Park units not presently supporting black-tailed prairie dogs include Carlsbad Cavern National Park (CAVE), Capulin Volcano National Monument (CAVO) Guadalupe Mountains National Park (GUMO), Lake Merideth National Recreation Area (LAME), Little Bighorn Battlefield National Monument (LIBI), (1995 phone survey of park resource management staff conducted by G.E. Plumb)



THRO
WICA
BADL
DETO
SCBL
FOLS
BEOL
CAVO
LAME
CAVE
GUMO

Figure 2. Layout of 4-ha (200-m x 200-m) visual count sample plot for estimating prairie dog density (adapted from Severson and Plumb 1998).

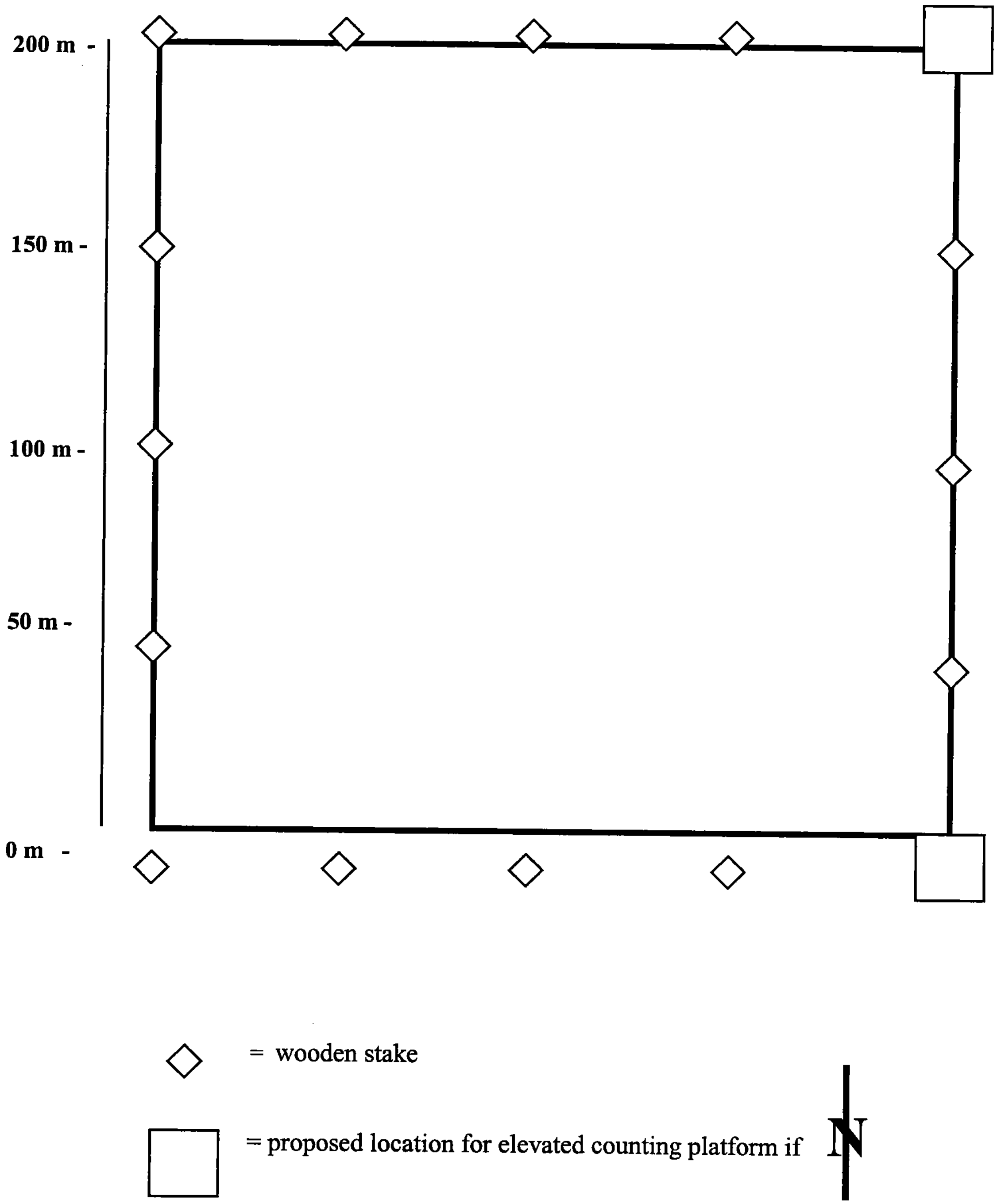

200 m -
150 m -
100 m -
50 m -
0 m -
= wooden stake
= proposed location for elevated counting platform if
N

Figure 3. Example prairie dog visual count data sheet.

Prairie Dog Visual Count Data Sheet

Park: ____________________ Year: ____________________

Town name ____________________ Observer ____________________

Day	Date	Start Time	End Time	Temp (°F)	Wind Speed (mph)	Wind Direction	Cloud Cover (%)	Precip.
1								
2								
3								

Day 1

Interval =	1	2	3	4	5	6	7	8
Start Time								
Count								
End Time								

Comments ____________________

Day 2

Interval =	1	2	3	4	5	6	7	8
Start Time								
Count								
End Time								

Comments ____________________

Day 3

Interval =	1	2	3	4	5	6	7	8
Start Time								
Count								
End Time								

Comments ____________________

Plot size (S_p) __________ either 4-ha, or total colony size, in ha, if smaller than 4-ha.

Prairie dog density = ([maximum observed value)/S_p]-3.04)/0.40;

Density = ([________/S_p] - 3.04)/0.40

Density = ________ (prairie dogs/ha)

Figure 4. Example prairie dog visual count data sheet filled out.

Prairie Dog Visual Count Data Sheet Filled Out

Park: Badlands
Year: 1997
Town name Upper Sage Creek
Observer Kevin Shinn

Day	Date	Start Time	End Time	Temp (°F)	Wind Speed (mph)	Wind Direction	Cloud Cover (%)	Precip.
1	7/16/97	0700	0900	69	5	N	20	0
2	7/17/97	0700	0900	70	10	N	0	0
3	7/18/97	0700	0900	72	7-10	NW	1	0

Day 1

Interval =	1	2	3	4	5	6	7	8
Start Time	0700	0715	0730	0745	0800	0815	0830	0845
Count	31	45	40	47	40	40	39	35
End Time	0705	0721	0735	0752	0806	0822	0835	0851

Comments 2 burrowing owls seen

Day 2

Interval =	1	2	3	4	5	6	7	8
Start Time	0700	0715	0730	0745	0800	0815	0830	0845
Count	55	45	47	46	47	80	84	81
End Time	0706	0720	0736	0752	0805	0822	0836	0852

Comments 4 antelope on prairie dog town

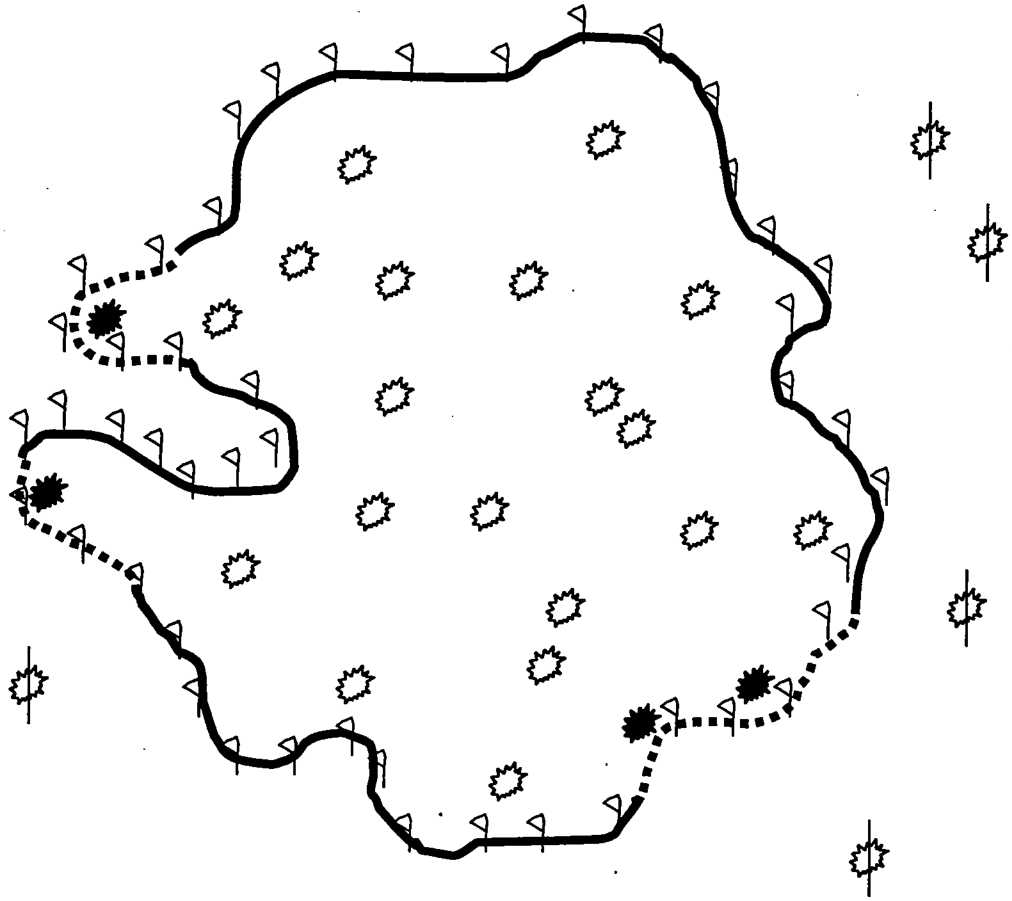
Day 3

Interval =	1	2	3	4	5	6	7	8
Start Time	0700	0715	0730	0745	0800	0815	0830	0845
Count	61	88	84	76	71	70	73	71
End Time	0705	0721	0737	0751	0806	0822	0835	0850

Comments 2-3 burrowing owls seen

Plot size (S_p) 4 either 4-ha, or total colony size, in ha, if smaller than 4-ha.
Prairie dog density = ([maximum observed value)/S_p]-3.04)/0.40;
Density = ([88/4] - 3.04)/0.40
Density = 47.4 (prairie dogs/ha)

Figure 5. Example of GPS delineation of a prairie dog colony edge using two boundary line criteria.



Legend

Colony boundary derived from visually detected clipped vegetation line

Colony boundary derived from visually detected active burrows within 5 meters of most recently clipped vegetation

Prairie dog colony active and inactive burrows

Active burrows within 5 meters of most recently clipped vegetation

Satellite burrows greater than 5 meters from colony boundary derived from active burrows within 5 meters of most recently clipped vegetation or clipped vegetation line.

Pin flags used to delineate the colony boundary for GPS mapping purposes

Appendix A. Contacts for reporting detection or strong suspicion of plague epizootics.

Below are listed the respective contacts (March 1998) which should be alerted upon detection or strong suspicion of a plague epizootic within or adjacent to a national park unit.

National Center for Disease Control (CDC) Contact
Dr. Ken Gage
Centers for Disease Control and Prevention CDC/DVBID
Foothills Campus, P.O. Box 2087
Fort Collins, CO 80522
(303) 221-6450; klg0@cdc.gov

Wildlife Disease Diagnostic Laboratory Contact
Dr. Beth Williams
Wyoming State Veterinary Lab
1190 West Jackson Street
Laramie, WY 82070
(307) 742-6638; storm@uwyo.edu

South Dakota (Badlands NP and Wind Cave NP)
Eileen Dowd Stukel
South Dakota Department of Game, Fish, and Parks
Joe Foss Building, 523 East Capitol Avenue
Pierre, SD 57501-3182
(605) 773-4229; FAX: (605) 773-6245; eileend@gfp.state.sd.us

North Dakota (Theodore Roosevelt NP)
Chris Grondahl
North Dakota Game and Fish
100 North Bismark Expressway
Bismark, ND 58501
(701) 328-6612; FAX: (701) 328-6352

Nebraska (Scotts Bluff NM)
Frank Andelt
Nebraska Game and Parks Commission
P.O. Box 30370
Lincoln, NE 68503
(402) 471-5427; FAX: (402) 471-5528; fandelt@ngpsun.ngpc.state.ne.us

Colorado (Bent's Old Fort NHS)
Dr. Margaret Wild
Colorado Division of Wildlife
317 West Prospect Road
Fort Collins, CO 80256
(970) 484-1093; FAX: (970) 490-6066

Kansas (Fort Larned NHS)

Keith Sexson - Chief of Wildlife Section
Kansas Department of Wildlife and Parks
512 SE 25th Avenue
Pratte, KS 67124
(316) 672-5911; FAX: (316) 672-2972

Wyoming (Devil's Tower NM)

Bob Luce
Wyoming Game and Fish Department
260 Buena Vista
Lander, WY 82520
(307) 332-2688; FAX: (307) 332-6669; bluce@missc.state.wy.us

Appendix B. Annual status report: 1999 Black-tailed Prairie Dog Monitoring for Scotts Bluff National Monument.

USGS
science for a changing world

Prairie Cluster Long-Term
Ecological Monitoring Program

Program Report
00-001

Annual Status Report:
1999 Black-tailed Prairie Dog Monitoring for Scotts Bluff National Monument

Annual Status Report:

1999 Black-tailed Prairie Dog Monitoring at Scotts Bluff National Monument

by
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January 2001

1.0 INTRODUCTION

1.1 Background

Prairie dogs (*Cynomys* sp.) once inhabited about 10 to 20% of the short and mixed-grass prairies of the United States (Anderson et al. 1986), but less than 1% of this historic range remains occupied (U.S. Fish and Wildlife Service 2000). The proximate causes for this decline include habitat loss due to conversion to cropland, urbanization, habitat modification and fragmentation, disease, and poisoning (U.S. Fish and Wildlife Service 2000). Additionally, the introduction of sylvatic plague (*Yersinia pestis*) into North America is presumed to be capable of causing massive prairie dog dieoffs (Barnes 1993; Cully 1993). The past and present status of the black-tailed prairie dog (BTPD), *Cynomys lucdovicianus*, in lands managed by the National Park Service (NPS) is poorly known. There are twenty-nine NPS units within the historic range of the BTPD. Twelve units historically supported BTPDs, but only seven units currently have BTPD populations.

Continual herbivory by BTPDs modifies the morphology, structure, and nutritive value of individual plants (Cid et al. 1989; Brizuela et al. 1986; Detling and Painter 1983; Holland and Detling 1990; Jaramillo and Detling 1988). The duration of colonization modifies the microhabitat along a disturbance gradient resulting in altered rates of microbial activity, nutrient cycling in soils, and water balance in plants (Archer and Detling 1986; Holland and Detling 1990; Whicker and Detling 1988). These impacts create a habitat mosaic that has been suggested to be beneficial to other species (Agnew et al. 1986; Sharps and Uresk 1990) such that in mixed prairie, approximately 40% of vertebrate wildlife species have some association (i.e., from obligate to accidental) with prairie dog colonies (Sharps and Uresk 1990). However, the small size and isolation of "island" fragments increase their vulnerability to changes in landuse, disturbance regimes, and diseases.

BTPD monitoring at Scotts Bluff National Monument (SCBL) and six other prairie parks began in 1995 to collect baseline data while simultaneously developing a monitoring protocol for the NPS Prairie Cluster Long-term Ecological Monitoring program.

1.2 Objectives

The objective of BTPD monitoring is to determine: 1) BTPD density and total abundance; 2) size and location of BTPD colonies, achieved by producing annual colony maps; and 3) surveillance of sylvatic plague.

2.0 METHODS

2.1 BTPD density and total abundance

The BTPD monitoring methodology is detailed in Plumb et al. (2000). There is only a single BTPD colony (<16 ha) at SCBL, so the entire colony is included in the counting. Sampling should be carried out during June and/or July: 1) when vegetation is at or near peak development but prior to senescence, 2) following emergence and prior to dispersal of young-of-the-year BTPD, and 3) when the BTPD-induced vegetation clip line colony "edge" is most easily discerned. Eight replicate counts, with 15-minute intervals between replicates, are made on each of three successive days, if possible. Counts should be completed between 1000 and 1100 hours each morning.

1. *BTPD predicted density* — Using the maximum count value among all counts, the predicted BTPD density, P, is calculated from the linear relationship described in Severson and Plumb (1998). In this linear model $P = ([Y/S_p] - 3.04)/0.40$, $r^2 = 64.6$, $P < 0.0001$, where

P = the estimated density of prairie dogs (individuals ha^{-1}) in the total area sampled,
S_p = the total area sampled, either the 4-ha sample plot, or total colony area if less than 4 ha; and
Y = the maximum visual count recorded over all plot counts

Using the data from Severson and Plumb (1998), the standard error (SE) of P can be calculated from the relationship:

$\text{Variance (P)} = MSE/b^2 (1 + 1/n + [P - \bar{x}]^2/\sum [x_i - \bar{x}]^2)$ where
MSE = mean square error = 10.1
b = 0.4
n = 24
$\bar{x} = 18.4$
$\sum [x_i - \bar{x}]^2 = 2512$

Variance (P) then becomes: $\text{Variance (P)} = 66 + 0.025 (P - 18.4)^2$, and $\text{SE (P)} = \sqrt{\text{Variance (P)}}$ (Neter et al. 1990).

2. *BTPD total colony population abundance* — Using the predicted density estimate, P, derived above, the total BTPD colony population abundance, T, is calculated as: $T = (S_c)(P)$, where S_c is the total colony area (ha) derived from the GPS survey. The SE of the abundance estimate is derived from:

S_c is the total colony area (ha) derived from the GPS survey.
The SE of the abundance estimate is derived from:
$\text{Variance (T)} = (S_c)^2 (\text{Variance [P]})$, and
$\text{SE (T)} = \sqrt{\text{Variance (T)}}$
(Neter et al. 1982)

3. *Interpreting changes over time* — Because the two BTPD metrics of interest, density (P) and abundance (T), represent a single annual value derived from the calculations above, there are limited options for statistical comparisons. Unreplicated data could be tested using the Z-test,

but that test does not account for potential autocorrelation problems which could occur especially if surveys are conducted annually. The best alternative is to calculate confidence intervals for the metrics, and compare those between years (Johnson 1999). Estimates with broadly overlapping intervals are not likely to be significantly different, whereas those with non-overlapping intervals would be clearly significantly different. The 95% confidence intervals for density and abundance, or any normally-distributed variable (Sokal and Rohlf 1969) can be calculated as:

Lower limit, P = P - 1.96 [SE(P)]
Upper limit, P = P + 1.96 [SE(P)]

Lower limit, T = T - 1.96 [SE(T)]
Upper limit, T = T + 1.96 [SE(T)]

where P and T are the quantities derived as described in section 2.1. The critical value of 1.96 is obtained from statistical tables (Rohlf and Sokal 1981) and represents the area of the t-distribution containing 95% of the parameter estimates for α=0.05 with n-1 degrees of freedom. The value for the standard errors of P [SE(P)] and T [SE(T)] are those calculated in section 1 and 2 above, respectively.

2.2 BTPD colony mapping

Plumb et al. (2000) describe the use of a Global Positioning System for delineating irregular land surface polygon boundaries and sizes in conjunction with PC-based Geographic Exploration Systems such as ArcView™.

Before conducting GPS mapping, use colored pin flags to mark the edge of the colony. Select a starting point, mark this point with a flag, and begin walking the colony edge in either direction, following the vegetation clip line. When the continuity of a vegetation clip line disappears or cannot be reasonably determined, continue to encircle the colony with an imaginary line that incorporates the extent of the active burrows (e.g., > 7 cm burrow opening with fresh scat within 0.5 m, *sensu* Biggins et al. 1993) within five meters of actively grazed vegetation. There may be exploratory burrows at great distances from the main colony, but burrows > 5 meters from actively grazed ground should be excised. Otherwise, extensive areas of uncolonized grassland could be included. While walking the colony edge, place the pin flags approximately 10 meters apart or at shorter, reasonable intervals that will clearly delineate undulating changes in the perimeter of the colony polygon. Completely walk the entire colony edge, arriving back at the initial flag, thus closing the colony polygon. Determine the area of the colony polygon by walking the entire marked perimeter using the GPS unit according to the manufacturer's specifications.

2.3 Sylvatic plague surveillance

Sylvatic plague is not known to be active in BTPD population in any NPS unit. Small parks such as SCBL, which has only one BTPD colony, are at highest risk of local extinction due to wildlife disease. In the absence of an ongoing epizootic, sylvatic plague surveillance takes the form of low-level local sampling paired with consistent liaison with state and local health departments and an informal surveillance network of biologically oriented public agencies and individuals (Barnes 1982). Upon evidence of activity or detection of plague locally, the appropriate state and local health agencies should carry out further surveillance.

Park staff should conduct an annual visual survey, denoting on a copy of the current colony map the estimated spatial extent of the active colony and a visual estimate of prairie dog numbers (0-10, 10-30, 30-120, 120-360, > 360). Surveys should be done between 0800 and 1000 (period of peak BTPD activity) with clear sky and low wind. Plotting abundance and distribution estimates across years will generate long-term trends from which dramatic order of magnitude deviation, indicative of substantial mortality and possible plague outbreak, can be detected. Upon evidence of a substantial decline in BTPD activity or detection of plague locally, the appropriate state and local health agencies should carry out further surveillance. Contacts to be alerted at this level of concern are listed in Appendix A.

3.0 RESULTS

3.1 BTPD density

The results of BTPD monitoring between 1995 and 1999 are given in Table 1. Population density estimates (± 95% confidence intervals) are shown in Figure 1, and total colony population size estimates (± 95% confidence intervals) are shown in Figure 2. Original data sheets were consulted for the count values used in 1996, 1998, and 1999. The original count data sheets for 1995 and 1997 were not available, and those maximum count values were derived from back calculations of reported densities (National Park Service 1997) using the Severson and Plumb (1998) regression.

Population density increased five-fold between 1995 and 1996, as the number of individuals increased while the colony size remained the same (Table 1). The lack of overlap between the confidence intervals for those two years indicates a significant increase. After 1996, population density declined as a result of expanding colony area, but the overlap in confidence intervals suggests the changes were not significant (Figure 1). Similarly, total colony population size increased significantly between 1995 and 1996 (no overlap of confidence intervals), increasing more than four-fold (Figure 2). Since 1996, the total colony population abundance remained stable until 1999, when it nearly tripled in size (Figure 2).

It is unknown to what extent important factors such as vegetation dynamics or weather may have caused the recent increases in the BTPD population. Long-term monitoring of these parameters in conjunction with continued monitoring of BTPDs will provide the best information for park managers to assess the magnitude of population changes and the causes of these fluctuations of BTPD numbers.

3.2 <u>BTPD Colony Mapping</u>

Maps showing the changes in the size, shape and location of the BTPD colony at Scotts Bluff from 1995 to 1999 are shown in Figures 3-6.

3.3 <u>BTPD Plague Surveillance</u>

To date, plague has not been known to have historically occurred at SCBL. Although active surveillance for plague, as described above, has not been carried out at SCBL, there has been no indication of possible plague noted during the abundance surveys.

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Table 1. Maximum black-tailed prairie dog count, estimated population density, total colony size derived through GPS mapping, and total colony population abundance of black-tailed prairie dogs at Scotts Bluff National Monument 1995-1998. Population density and total colony population abundance estimates are shown ± standard error.

Year	Maximum count	Population density (individuals ha^{-1})	95% Confidence interval	Colony size (ha)	Total colony population size (individuals $park^{-1}$)	95% Confidence Interval
1995	11	12.0 ± 8.2	-4.1 to 28.1	1.4	16.8 ± 11.5	-5.7 to 39.3
1996	34	53.1 9.8	33.9 to 72.3	1.4	74.3 13.7	47.4 to 101.2
1997	38	28.9 8.3	12.7 to 45.2	2.6	75.1 21.6	32.8 to 117.4
1998	40	22.7 8.2	6.6 to 38.8	3.3	74.9 26.9	22.2 to 127.6
1999	102	20.4 8.1	-4.5 to 36.3	9.1	185.6 73.7	-41.1 to 330.1

Figure 1. Estimates of black-tailed prairie dog densities (individuals ha^{-1}), $\pm$ 95% confidence intervals from 1995 through 1999 at Scotts Bluff National Monument.

SCOTTS BLUFF NATIONAL MONUMENT

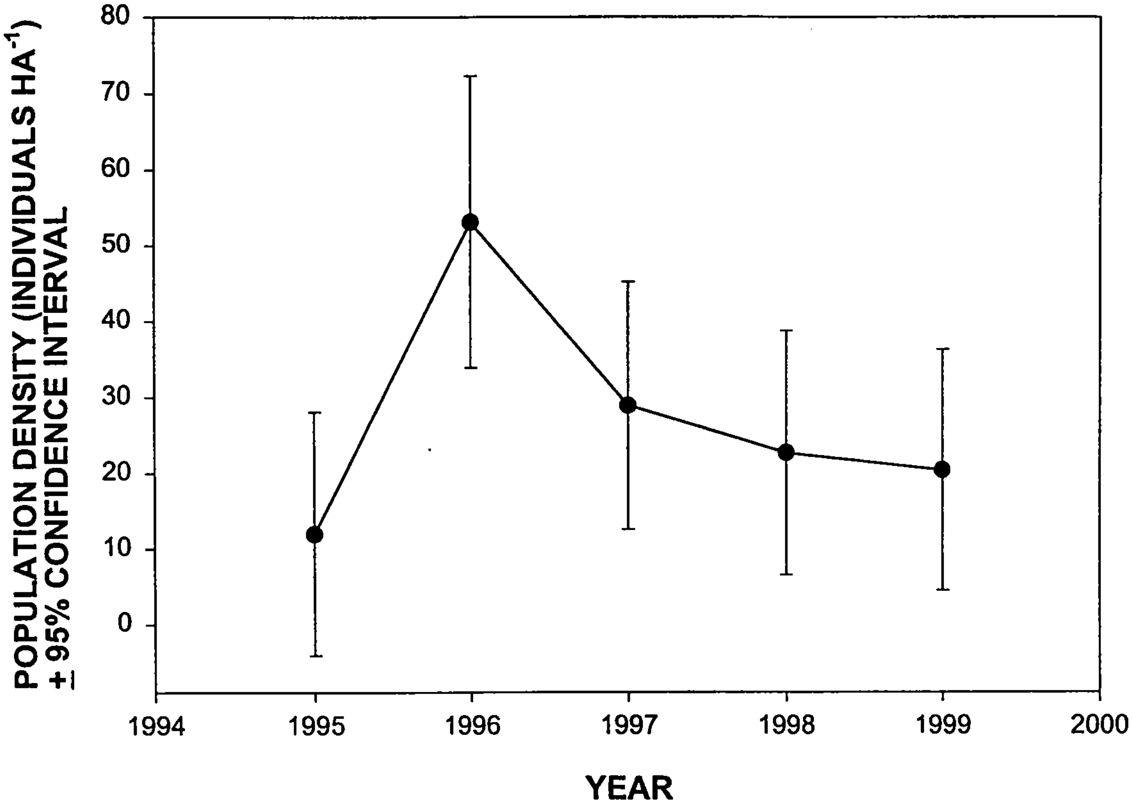
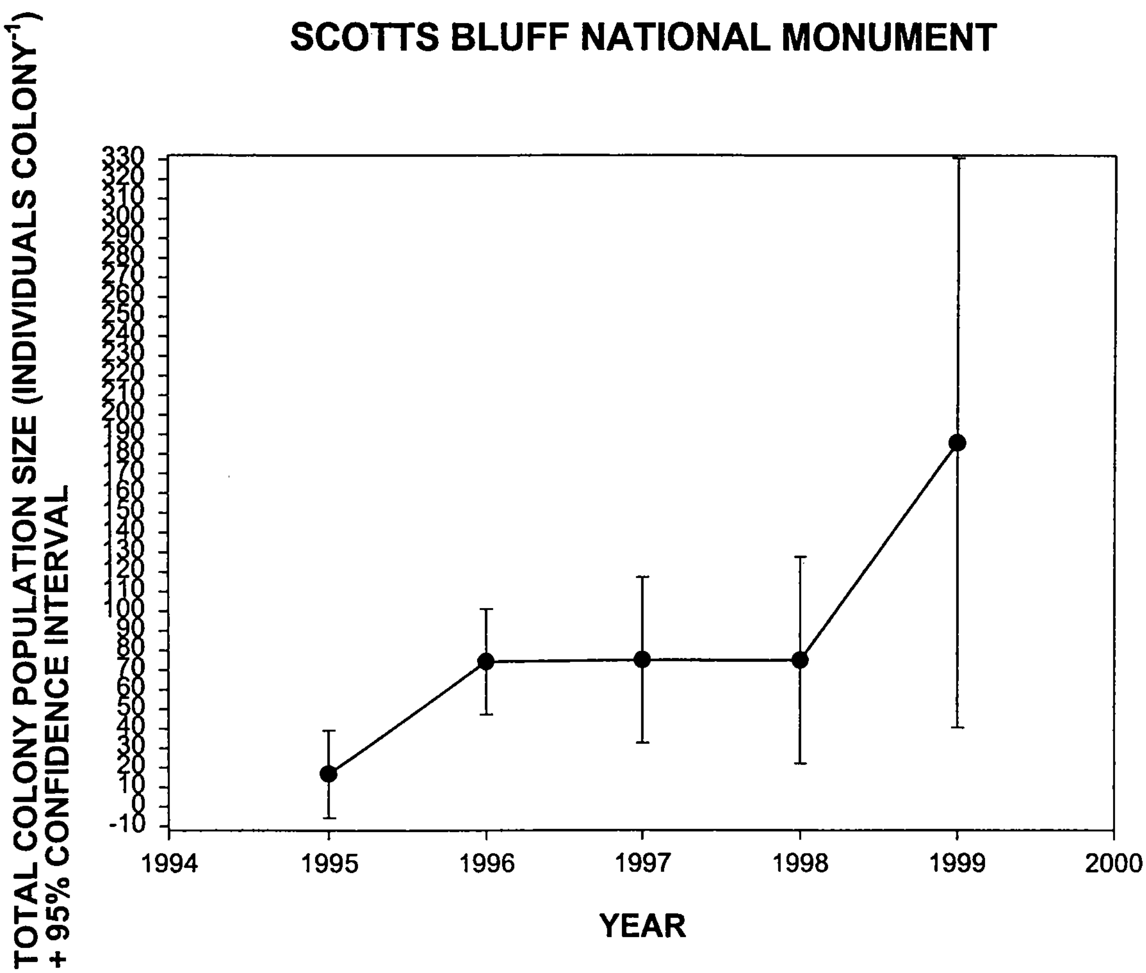


Figure 2. Estimates of black-tailed prairie dog total colony populations(individuals colony^{-1}), $\pm$ 95% confidence intervals from 1995 through 1998 at Scotts Bluff National Monument.



SCOTTS BLUFF NATIONAL MONUMENT
TOTAL COLONY POPULATION SIZE (INDIVIDUALS COLONY-1)
+ 95% CONFIDENCE INTERVAL
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
1994
1995
1996
1997
1998
1999
2000
YEAR

Figure 3. Map of the black-tailed prairie dog colony at Scotts Bluff National Monument in 1995.

Figure 4. Map of the black-tailed prairie dog colony at Scotts Bluff National Monument in 1997.

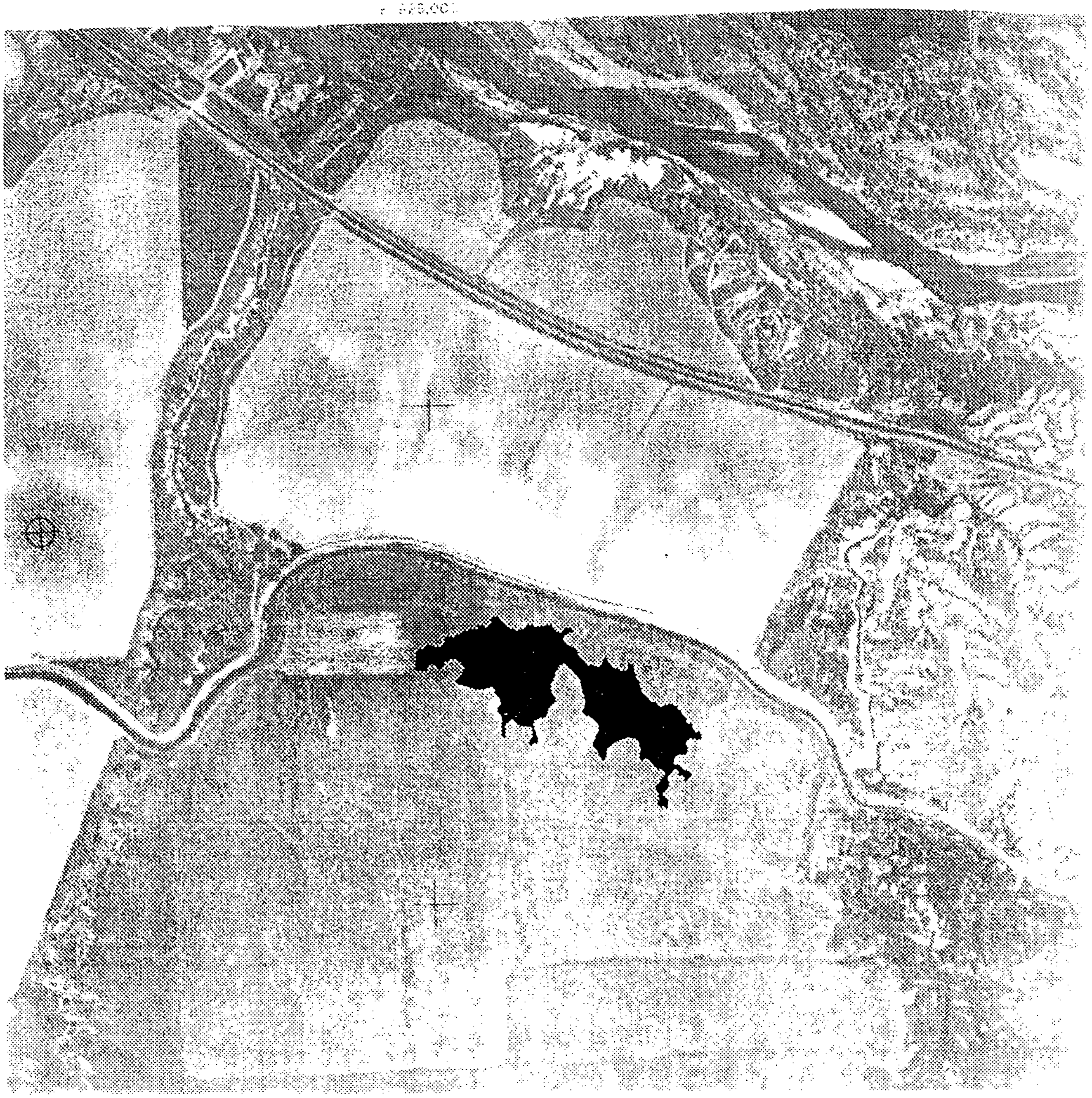
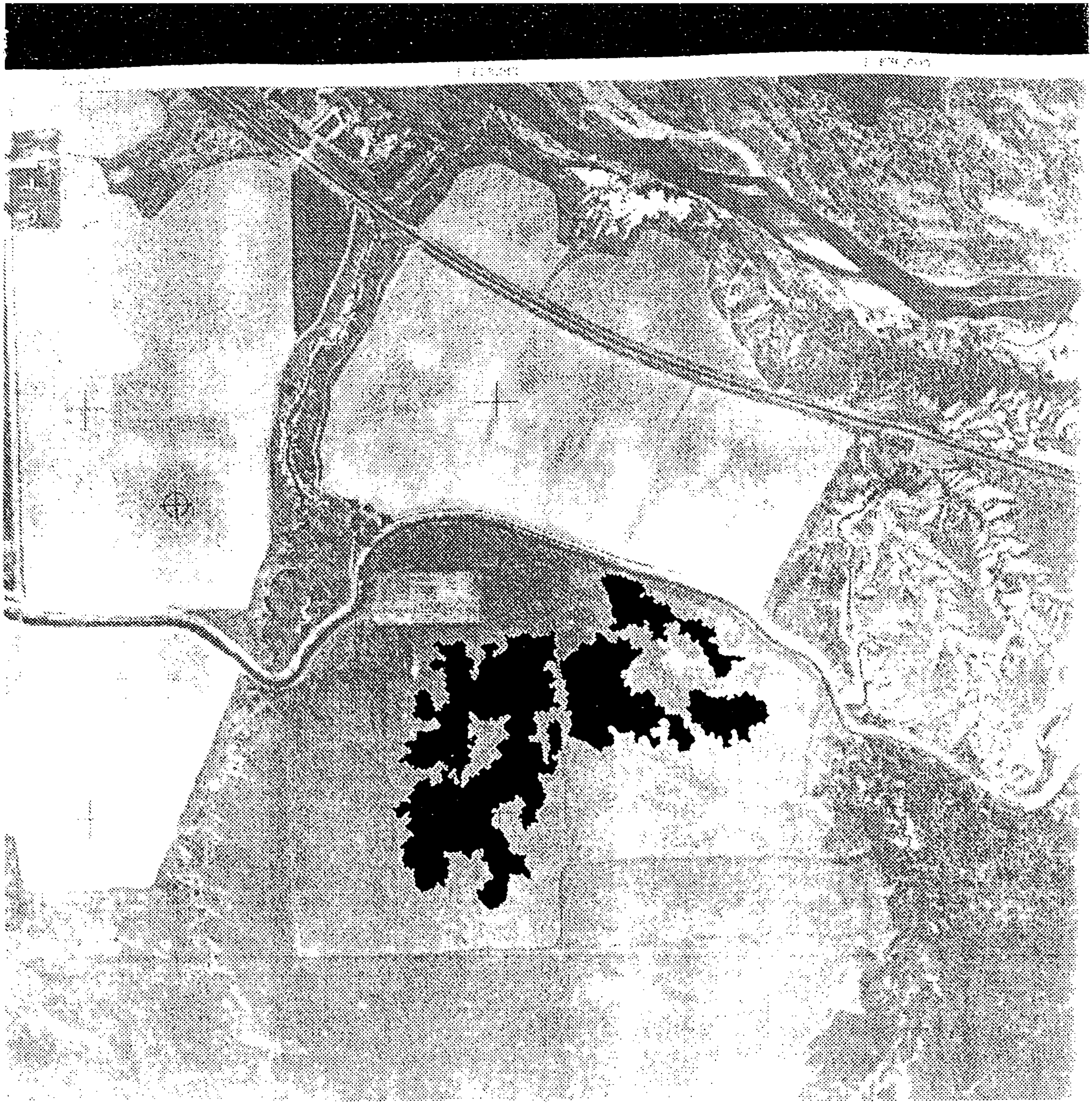


Figure 5. Map of the black-tailed prairie dog colony at Scotts Bluff National Monument in 1998.

Figure 6. Map of the black-tailed prairie dog colony at Scotts Bluff National Monument in 1999.



Appendix A. Below are listed the respective contacts (as of March 1998) who should be alerted upon detection or strong suspicion of a plague epizootic within or adjacent to Scotts Bluff National Monument.

National Center for Disease Control (CDC) contact

Dr. Ken Gage
Centers for Disease Control and Prevention CDC/DVBID
Foothills Campus, P.O. Box 2087
Fort Collins, CO 80522
(303) 221-6450; klg0@cdc.gov

Wildlife Disease Diagnostic Laboratory contact

Dr. Beth Williams
Wyoming State Veterinary Lab
1190 West Jackson Street
Laramie, WY 82070
(307) 742-6638; storm@uwyo.edu

Nebraska (Scotts Bluff National Monument)

Frank Andelt
Nebraska Game and Parks Commission
P.O. Box 30370
Lincoln, NE 68503
(402) 471-5427; FAX: (402) 471-5528; fandelt@ngpsun.ngpc.state.ne.us